being largely composed of lowland, calcicole, and aquatic or paludal species; the marginal of calcifuge, upland and dry-soil plants. Well-marked northern and southern, eastern and western groups also exist, the boundaries between them consisting of lines running not exactly east and west or north and south, but rather north-north-eastward from Cork to Londonderry and east-north-eastward from Galway Bay to Dundalk Bay. For these six types of distribution the author proposes the names Central, Marginal, Ultonian, Mumonian, Lagenian, Connacian, the last four being taken from the old names of the four provinces of Ireland, in each of which one of the groups attains its maximum. The characters of each plant-group, and its relations to the climatological and physiographic features of the country, were pointed out.

Two papers of economic importance were read. Prof. Johnston showed the distribution of peat bogs in Ireland by means of a new map prepared by the Intelligence and Statistical Branch of the Irish Agricultural and Technical Instruction Department. They cover 1861 square miles, chiefly in counties Donegal, Mayo and Galway, and have an average depth of 25 feet. An account was given of the character of the different layers of a bog as seen in a vertical section, and an explanation suggested of the origin of a bog-slide. Specimens of the bog-flora, of the different kinds of peat and of the economic products derivable from turf or peat, lent from the botanical collections of the National Museum in Dublin, were exhibited. The second paper, by Mr. R. B. Buckley, on colonisation and irrigation in Uganda and the British East African Protectorate, began with a clear picture of the existing physical and economic conditions of these dependencies, and enunciated comprehensive and judicious views as to their development in the future. The question of irrigation was exhaustively treated, and the author concluded that the prospects of great transformations taking place through its aid are not very hopeful.

A. J. H.

ENGINEERING AT THE BRITISH ASSOCIATION.

On Thursday, September 11, after the president's address, a paper by Mr. H. A. Humphrey on recent progress in large gas engines was read. This paper, which was illustrated by lantern slides, gave an account of the extraordinary development of large gas engines which has taken place during the past few years, and which has, as the author said, had but few parallels in the history of engineering enterprise. In the Paris Exhibition of 1900, a 600 h.p. Cockerill gas engine was, from its size, the object of much interest. The same makers are now building engines of 2500 h.p., and they are prepared to undertake one to develop 5000 h.p. In this country it is only as recently as 1900 that engines above 400 h.p. have been made, the first two being constructed for Messrs. Brunner, Mond and Co.'s works at Winnington, yet when the paper was written (August) the two chief manufactories in Great Britain had under contract or had already delivered no less than fifty-one gas engines ranging in size between 200 and 1000 h.p. But it is on the Continent and in America that the most remarkable advance has been made. The author gave in a very complete table particulars of all engines of more than 200 h.p. capacity which have been built abroad or are under construction, the total amounting to 327 engines, developing 181,605 h.p. Slides shown by the author illustrated the various uses to which these large gas engines have been put so far, such as dynamo driving, air compression for blast-furnace work, and other similar uses. Perhaps the most interesting detail in connection with this increase in the size of gas engines has been the use of blast-furnace gas for working them. The author in the latter part of his paper explained in some detail the improvements in construction and governing which have made these large engines possible, in particular the changes which have been necessary in the old "hit and miss" governor mechanism, where, as in dynamo driving, perfect uniformity of speed is necessary. As several large engineering firms in this country have now acquired the rights for manufacturing some of the most successful foreign types of these engines, there is little doubt that we are on the eve of important developments in this country in the gas-engine industry, especially in the utilisation of producer and of blast-furnace gases.

In the afternoon of September 11, the Section made a special visit to the harbour works, under the guidance of the engineers to the Belfast Harbour Commissioners, in order that members might see for themselves some of the remarkable developments which have taken place in Belfast Harbour and have been brought about by constant increase in the size of ocean steamships.

On Friday, September 12, the first paper was a brief communication by the Hon. C. A. Parsons on steam turbines, in which figures were given to show the rapid increase in the use of the compound turbine since 1884. Up to 1890, though a number of compound turbines had already been constructed for driving dynamos, the largest size had not exceeded 120 h.p., the total h.p. at that date being 5000; by 1896 the total h.p. had increased to 40,000 and the largest individual plant to 600 h.p., and now the largest unit has increased to 3,000 hp. and the aggregate h.p. sold in Great Britain to 200,000. On the Continent, also, their use has been rapidly extending, and the total aggregate of horse-power at home and abroad for driving dynamos up to the present time is not far short of 300,000. As a proof of the remarkable economy obtained in the very large machines, the author stated that a steam consumption of 17·3lb. per kilowatt hour had been recorded during a test of a 1000 kilowatt continuous-current machine belonging to the Newcastle and District Electric Light Company; this would be equivalent to about 10·2lb. of steam per i.h.p. hour, a very remarkable figure, and he anticipates still greater economy in the future in turbines of large size when using superheated steam. Many engineers had feared that these machines would fall off notably in their economy after they had been running for some time, but the author stated that careful tests had now been made with several plants to determine the steam consumption after the machinery had been in use for several years, and no appreciable increase had been found. The second half of the paper was devoted to an account of the application of the steam turbine to marine work; seven vessels have so far been fitted with turbine engines, including the two unfortunate destroyers—the *Cobra* and the *Viper*—and the two well-known Clyde passenger boats—the *King Edward* and the *Queen Alexandra*. In addition to these, a third-class cruiser, the *Amethyst*, would shortly be completed, and orders have recently been placed on the Clyde with Messrs. Denny Bros. for the construction of two cross-channel boats which are to have turbine engines of about 8000 h.p.; this means a total of about 83,000 h.p. in use or in construction. Mr. Parsons stated that if the coal consumption of the *Duchess of Hamilton* (fitted with ordinary reciprocating compound engines) was compared with that of the *King Edward*, and if various allowances for the difference in speed of the two boats and for various other factors were made, then the turbine boat showed a saving of 20 per cent.; he again, as at the Dover meeting, prophesied the eventual use of turbine engines for Atlantic liners, cruisers and battleships. In his reply to a brief discussion, in which several points were raised with regard to the use of superheated steam in the turbines, the author stated that he estimated a gain of efficiency due to superheating of about 1 per cent. for every 10° of superheat.

The next matter dealt with by the Section was the report of the Committee on the Resistance of Road Vehicles to Traction, the first eleven sections of which were devoted to a complete *résumé* of the experimental work which has already been carried out on this subject, and to a summary of the opinions which have so far been expressed (based on these experiments) of the effects on traction on the level of the three independent elements of road resistance, namely, axial friction, rolling resistance and grade resistance. The last two sections of the report were devoted to a brief description of the special apparatus which has been designed and made by the Committee; the first series of experiments undertaken will be confined to measurements of the resistance of single wheels. The tractive force will be transmitted through a system of levers to a small ram which presses upon a rubber diaphragm enclosing a space filled with water or other liquid; the pressure exerted by the levers on the ram will vary with the tractive force, and the consequent varying fluid pressure will be registered by a recording pressure gauge of the Bourdon tube type, and since the drum of the instrument carrying the recording paper will be rotated in strict accordance with the movements of the car, a diagram will be drawn giving the tractive force at all points on the journey. The instrument has been so designed that the leverage on the ram can be altered to ensure diagrams of a reasonable size even when the tractive force is very small, and a revolution counter will be used for obtaining independently the revolutions of the experimental wheel. Several preliminary experiments have already been carried out, but the main work of the Committee will be undertaken during the forthcoming year. It should be mentioned here that although another grant was given to the Committee by the Association, still its work will be terribly hampered, and in fact will be almost impossible, unless additional funds are forthcoming from other sources; the Committee is doing work of such great importance to the country that it is to be hoped public bodies and all those who are interested in the question of the construction and upkeep of public streets and roads and the best means of road traction will respond liberally to the appeal which the Committee has issued for financial help.

Two other important papers read on this day dealt respectively with the rainfall and water-power available in Ireland. Dr. Mill exhibited a map of Ireland coloured to show the distribution of rainfall, as ascertained from the records of the ten years 1890–1899, and pointed out that practically the whole country west of the Foyle and the Shannon, and west and south of a line drawn from Limerick to Clonmel, had a rainfall exceeding 40 inches in the year. He also gave some interesting statistics as to the number of rainfall stations in Ireland and the increase since the Belfast meeting in 1874; he calculated that 185 additional observers would be required to secure as many rain-gauge observations per 1000 of population as were now made in England. Perhaps as a result of this meeting we may again find an increase of interest taken in this important question.

Mr. Dick, in his paper on the water-power available in Ireland, considered only the cases of the Shannon, the Erne and the Bann, perhaps the most important rivers, however, from a power point of view. The dry-weather minimum flow of these rivers is the vital factor in calculations of available power, and the problem is rendered exceptionally difficult owing to the conditions which have been laid down in reference to this minimum flow in Acts of Parliament which have been passed in connection with the fishing industry in these rivers. Mr. Dick stated that very careful measurements had been made of the amount of water available under the above conditions, and he calculated that as a result the continuous water-power available on the lower Shannon would be nil, on the lower Erne 400 and on the lower Bann 800. He then dealt with the possibility of increasing this small horse-power by storage of flood waters, and came to the conclusion that this was out of the question when regard was paid to the enormous amount of money which had already been spent for the purpose of keeping these rivers at or near their summer level in connection with the requirements of arterial drainage and navigation. It will be seen that the author's figures correct the serious misconceptions that have prevailed in regard to the amount of water-power likely to be available in Ireland; no doubt these too favourable views have arisen from the erroneous figures given by Sir Robert Kane in his book on the "Industrial Resources of Ireland," since that author estimated that the available water-power on the Shannon alone between Killaloe and Limerick was 34,000. Several of those who took part in the discussion were of opinion that the author had taken a too pessimistic view of the situation, and that in several cases, at any rate if useless navigation rights were abandoned, considerable power would be rendered available.

The meeting on Monday, September 15, was, as usual, devoted to electrical papers, and the first paper dealt with was a suggestive one by Mr. J. E. Kingsbury on the future of the telephone in the United Kingdom. The author gave a short history of the various telephone companies which have been at work in this country from the date of the famous action brought against the Edison Telephone Company by the Post Office in 1880, and then went on to show that competing services which had been started in one or two towns, as for example, Dundee, Sheffield and Manchester, had not benefited the community; in fact, the people of those towns had actually derived an advantage from the amalgamation of the local competing companies with the National Telephone Company, a view, we may point out, quite opposed to the popular ideas upon that subject. Mr. Kingsbury was of opinion that competing services had ceased in the past because the absurdity of such a situation was obvious as soon as it was put into practice. Parliament, by the Act of 1899, determined to foster once more, by the help of the ratepayers, this system of competition, although when tried before under private enterprise it had proved unsatisfactory. Both in Glasgow and in Tunbridge Wells, where municipal telephone systems had been started, the author was of opinion that money had been uselessly spent simply to create a system of duplicate subscribers and duplicate subscriptions. In London, on the other hand, an admirable arrangement had been concluded by the Postmaster General by which every subscriber to the Post Office system was in connection with the existing 45,000 subscribers to the old system. In conclusion, he stated that as corporations could borrow money easily and cheaply, it would be spent on competitive systems which were wasteful, and gave the maximum of inconvenience and the minimum of public benefit. Several of those who took part in the discussion were opposed to the position taken up by the author on the question of municipal telephone systems, but Sir William Preece appeared to uphold the idea that a general telephone system could be much better worked by the Post Office than by separate municipalities. One of the speakers declared, as the result of careful inquiry, that the Glasgow telephone system, instead of being a failure as the author had stated, was a great success.

Prof. E. Wilson then read a paper on the electrical conductivity of certain aluminium alloys as affected by exposure to London atmosphere. A number of specimens of various light aluminium alloys had been placed on the roof of King's College, London, in order to investigate the effect of exposure to the atmosphere. The specimens were wires about $\frac{1}{8}$ inch in diameter, carried on a wooden frame, and had been exposed for about thirteen months. A table was presented by the author giving the results of the experiments, and as chemical analyses had been made in every case, the author was able to show the effect upon the specific resistance of each alloy of the different elements in combination with the aluminium; as a result of his work, he concluded that for exposed light aluminium alloys copper alone should not be used; on the other hand, the presence of equal amounts of nickel and copper, about 1 per cent. of each, though it slightly reduced conductivity, produced a marked improvement in power to resist corrosion. Dr. Glazebrook, in the discussion, mentioned how difficult it was in such experiments to determine accurately the specific resistance owing to the pittings and cracks which were produced on the surface by the action of the weather.

Another paper of much interest was one by Mr. W. Taylor on the science of the workshop. He said that the subject would divide itself naturally into three parts—the materials used in the workshop, the processes for their treatment, and tools; and in the section on materials he pointed out truly enough that much of the work which had hitherto been carried on in technical schools and also by original investigators had been confined to the study of the physical properties of materials from the point of view of the designer, whose chief interest is that his machine structures shall not be strained beyond the elastic limit, rather than from the point of view of the mechanic, whose business it is to shape the materials, generally by straining them beyond the elastic limit. He hoped for considerable advance in our knowledge from this latter point of view, from the photomicrographic study of the structure of materials and from such researches as those which have been carried out by the Alloys Research Committee of the Institution of Mechanical Engineers.

The last paper on the programme for the day was one by Mr. J. R. Wigham on a new flashing lighthouse light without intervals of darkness. One of these lights was placed on the top of the tower of Queen's College and was shown in operation each night during the meeting. The author stated that the cost of the new light, which was practically a continuous one, was not greater than that of any other of the first-class lights with revolving annular lenses, and that any common illuminant might be used.

The afternoon of Monday was devoted to a joint discussion with Section L on the training of engineers. The discussion was opened by the president of the Section, Prof. Perry; it was, in fact, a discussion of his presidential address to Section G. One of the points mentioned by the president was the necessity that engineers and manufacturers should interest themselves in the question of the education of the young engineer, and that until they do so engineering teachers cannot hope to meet with success. We feel sure that this want of interest is at the bottom of much of the trouble the directors of engineering schools now experience in inducing parents and guardians to consider that the profession of an engineer is one which requires in the present day as lengthy and complete a preparation as medicine or law. Several speakers raised the question as to whether it was advisable to adopt what has been called the half-time course, that is to say, the system under which students attend the university or technical college classes during the winter and work in the shops or drawing offices during the summer. We may mention that this plan has been carried out in several towns, but as a rule employers are somewhat opposed to it. Sir William Preece declared—and it is a statement which cannot be too often made—that it is at the top and not at the bottom that we require radical changes in our technical education for engineers.

On Tuesday, September 16, a number of general papers were dealt with. The first paper, by Mr. W. H. Booth, treated of the smokeless combustion of bituminous fuel, and the author contended that as a rule boiler furnaces were badly designed in respect of the prevention of smoke. Furnaces must be arranged in such a way that all the gaseous products of the furnace are swept together with the admitted air, and are not cooled down until sufficiently burnt to admit of their being used for heating purposes; and he was of opinion that there was nothing in smoke prevention to justify the assertion that it was economically impossible. Mr. J. S. Raworth, in connection with this subject, described a system for the prevention of smoke known as the "Wilson smokeless process." A small quantity of nitrate of soda in solution is injected into the furnace with sufficient air to give perfect combustion, the cost being about 3*d.* to 4*d.* per ton of coal burnt; this system has been installed in a tobacco factory in Belfast, smoke has been abolished, and the output and efficiency of the boilers improved.

Prof. G. Forbes then gave an interesting account of his experiences in the late South African war with the infantry range-finder, which he described at the Glasgow meeting last September. Both officers and men who had served at the front were unanimous in their opinion that the great want which had so often nullified the strategy of our leaders and endurance of our men was a quick, handy, trustworthy one-man range-finder. In actual service this range-finder had proved that its accuracy was all that could be desired, and it was much quicker in action than the mekometer. During a trek of 300 miles in eleven days, he had been constantly called upon to give distances, and it never took longer than one minute to dismount from his horse, set up the range-finder and give the first range, other ranges being given in a few seconds. He was in action for two days, and was able to give the ranges quickly and accurately without any unnecessary exposure. With his own eyesight, which was not particularly good, he was able to get an accuracy of 2 per cent. in 3000 yards, but many of the men had been able to get a very much greater degree of accuracy than this.

Several other short communications were read, but we have not space to deal with them.

T. H. B.

SCIENCE AND LITERATURE.[1]

On what subject ought one to speak at the beginning of the session of a College of Science which is also a School of Applied Science, speaking, not only to one's colleagues, but to new and old students who differ from one another in character, training, social position and attainments more than the students of any other college probably in the world? This college has three functions. It gives the highest possible instruction in mathematics and natural philosophy and in all the natural sciences. It gives technical instruction to mining, metallurgical and mechanical engineers. It gives pedagogic training to teachers of all subjects taught at the college. The presence of Sir Arthur Rücker, Principal of London University, reminds me of a fourth function which has recently been added—namely, the preparation of students to pass university examinations.

I am strongly of opinion that every engineer—that is, every man whose business it is to apply any of the physical sciences—ought to have a more or less thorough training as a mechanical and electrical engineer. In the address which I had the honour to deliver three weeks ago as president of the Engineering Section of the British Association, I tried to show that only a very exceptional student can obtain such training unless he spends much time in mechanical or electrical engineering laboratories such as I there described. For many years, from long before I came to Kensington, the mechanics course here has been one in mechanical engineering as well as in mechanical philosophy. My anxiety to own a laboratory has met with the utmost sympathy from the higher authorities and the council of the college. I may say that we are all as anxious that students should work with electric generators and motors and other electric-power plant as with steam and gas engines, with water turbines and pumps. I know that some of you blame me because I can give none of this necessary instruction, and sometimes, perhaps, I blame others for not affording me facilities. The curriculum at this college was arranged a great many years ago, when people aimed only at the training of the exceptionally clever student, and, indeed, before any electrical appliance was used by miners or metallurgists; before the time when a mine became filled with mechanical contrivances. Every mining or metallurgical or other technical school now established in any part of the world gives this sort of training to the students which we are unable to give. The authorities of this College are in sympathy with you and with me, and would help us to this necessary laboratory work and greater space and other facilities for instruction in my division if they possibly could. Parenthetically, I may observe that, in so far as applied mechanics and engineering theory are concerned, the courses of study here will enable any willing student to obtain the highest engineering degree of the University of London.

Some of you are extremely well read in scientific text-books, having passed most severe examinations in pure and applied science. And not mere text-books, but real scientific books have been studied by many of you; for I know that some of you have dipped into Larmor's book on the ether, and have read Thomson and Tait and Maxwell and Rayleigh. Not only have you this wonderful knowledge in science, but you have been earning your own living and you have developed an instinct for taking advantage of chances, of fending for yourselves, of making other people do what you ask, that is perfectly marvellous. Some of you remind me of great fir-trees that I saw in Norway this summer, spreading their roots over a rocky soil, gaining sustenance where no other kind of tree could exist. One power more developed than another is that of passing examinations. Nobody who is without the experience of an examiner of candidates from the evening science classes can comprehend your power of getting marks from a careless examiner for answers to questions on subjects about which your knowledge is limited. There is hardly any town in the British Islands from which our scholars—I suppose that quite a hundred scholars are here—have not come, each picked from many hundreds or thousands, each the recipient of great honour and a valuable scholarship, and your townspeople and your old companions are keeping their eyes on you, wondering whether or not it is a great man of the future that has been sent up to us. And now for the other side. You know much of what has been done, but have you the power to discover, to add to the world's knowledge? Your knowledge has been derived from books and lectures; you have now to learn that a week in the laboratory, during which you seem to crawl, during which for examination purposes you do less than in reading ten lines of a text-book, is really of more value to your scientific education than a month's hard reading. This is almost unbelievable to you who are such adepts in passing examinations; yet it is quite true. Lectures and lessons have spoon-fed you until now; lectures and lessons will in future teach you to feed yourselves.

Again, many of you think it is not only a waste of time, but a positive sin, to read novels and poetry and general literature, to cultivate in any way the imagination, to take an interest in painting or sculpture or music. You have yet to learn that although parrots and other imitative animals can get on without imagination, there is no such thing in existence as an unimaginative scientific man. That you have some imagination and individuality is evidenced by your differentiation from all other students of science classes; but have you these well developed, and have you those other qualities which are absolutely necessary for the success of a scientific worker? Imagination is far and away the most important; but there are also judgment and common sense, and the love of truth and the power of self-sacrifice, which seem always to accompany the pursuit of science. Are you fond of reading? Do you know how to use books? Can you explain with decent sketches what you observe and know? Mere learning is a poor thing, but fondness for reading leads to the greatest possible development of all one's

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[1] Abridged from the inaugural address delivered at the Royal College of Science (with which is incorporated the Royal School of Mines), London, by Prof. John Perry, M.E., D.Sc., LL.D., F.R.S., Professor of Mechanics and Mathematics, on October 2.